REPORT OF THE TASK FORCE ON REDUCING COSTS OF DEFENSE SYSTEMS ACQUISITION. "DESIGN-TO-COST, COMMERCIAL PRACTICE VS. DEPARTMENT OF DEFENSE PRACTICE"

Office of the Director of Defense Research and Engineering
Washington, D. C.

15 March 1973

Defense Science Board

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THE DEPUTY SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

MAY 14 1973

MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

THROUGH: THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

SUBJECT: Report of the Defense Science Board Task Force on Reducing Costs of Defense Systems Acquisition -- "Design-to-Cost, Commercial Practice vs. Department of Defense Practice"

I have reviewed the subject report and find it particularly stimulating and worthwhile. I recognize the significance of the Task Force recommendations.

I note that Item 1 of the cultural changes recommended in Mr. Bucy's Memorandum indicates that DoD negotiations for production focus only on cost justification and not on price. I believe the Task Force should recognize that fixed price production contracts are negotiated as price rather than cost. The negotiations are based on price analysis when appropriate. Often "cost analysis" is necessary because insufficient data is available or lack of competition does not permit price analysis. When cost reimbursement contracts are used, cost analysis techniques must be applied, as there is no other basis for price analysis.

I desire to be kept informed of the progress in implementing these recommendations for utilization of commercial principles and practices where applicable for designing to a cost and improving the management of our major defense system acquisitions.

Because of the importance and timeliness of the subject report, it will receive widespread distribution throughout the Department of Defense and defense industry as soon as possible.

Finally, I would like you to express my deepest appreciation to the Chairman and all the Members and Consultants of the Task Force for their participation in the preparation of this report. I know these men contributed a great deal of their own time and talent. Their recommendations on how to improve the Government/Industry interface and how to strengthen the Government/Industry team in support of our national defense are appreciated.

M. P. Clements

Copy to:
Assistant Secretary of Defense (Comptroller)
Assistant Secretary of Defense (Installations and Logistics)
Director, Defense Program Analysis and Evaluation

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

15 March 1973

TO: THE SECRETARY OF DEFENSE

THROUGH: THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

The attached report of the Defense Science Board Task Force on Reducing Costs of Defense Systems Acquisition was prepared at the request of the Director of Defense Research and Engineering. The Task Force, under the chairmanship of Mr. J. Fred Bucy, Jr., was chosen to include members with a wide variety of experience in commercial industry.

In his memorandum of transmittal, Mr. Bucy emphasizes that the recommendations of the Task Force regarding "designing to a cost" should be seriously implemented by the Department of Defense and points out the danger that mere lip service rather than substantive action can reduce the proposed acquisition philosophy to a "buzz phrase." The report has been approved by the Defense Science Board and I recommend it to you for your consideration.

Joseph V. Charyk
Vice Chairman
Defense Science Board

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

1 March 1973

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of Task Force on Reducing Costs of Defense Systems Acquisition

The final report presents the key findings and recommendations of the Task Force. As in any human endeavor, it is much easier to recognize a problem than to solve it. Mindful of this, the members have stated the findings as "what we find to be good commercial practice, applicable to DoD," rather than as "what is wrong with the status quo." There are many good practices in industry and DoD that cannot be transplanted. These are not discussed in this study.

Since our objective is to set forth clearly and simply how "design-to-cost" could work, the report does not address the complex socio-political environment in which DoD must operate. Therefore, the result, at times, may appear naive. This is done purposely, to make points clear without burdening them with a number of qualifying statements or exceptions. Obviously, these statements if taken out of this context may appear inappropriate.

I believe our recommendations can be implemented, if the decision is made to do so. Some of the recommendations may be used as goals, toward which DoD should strive and direct its energy, and thereby realize more cost-effective Defense Systems.

"Design-to-cost" establishes, as a design goal, a unit production cost which the DoD can afford to pay (for the quantities it needs) as a primary design parameter (equal with performance). It requires that cost be continuously emphasized in trade off decisions, and requires the contractor to demonstrate this cost on an incremental basis before award of the production contract. It is a means of countering high unit production cost and unnecessary system sophistication and complexity.

Continual reference to this effort as "design to-cost" gives us real concern. The danger is that lip service to this new "buzz phrase" will be used in place of any real substance in accomplishment of "design-to-cost."

Although the Task Force recognized the absolute importance of having credible cost estimates for both production and operating costs as an aid to design and management decision-making at all stages of the system acquisition process, the subject of improving cost estimating is not dealt with in this study since it has received, and is receiving, considerable attention elsewhere.

In submitting these recommendations, the Task Force has one overriding reservation. The reservation is that, without major changes in the defense acquisition culture that now exists, the outlook for effective "design-to-cost" will not be at all promising. The nature of the cultural changes that, in our judgment, appear to be required are characterized by the following statements:

1. The present process of contract negotiation and award for production phases should be changed from one that focuses on cost justification to one which is based on price. This would, in turn, militate against the practice of detailed cost justifications for production contracts, which in almost every instance lead to cost growth. This is not a recommendation for Total Package Procurement; R&D and some production prototypes should be done with CPFF contracts and/or incentive contracts.

2. DoD personnel, both uniformed and civilian, at all levels, must be motivated and held accountable through a more effective system of awards and penalties.

3. DoD's hierarchy of defense acquisition management must be simplified, and the project manager must be given full authority, with the "ilities," procurement, and inspection agencies subservient to him.

   The Task Force particularly underscored the vital importance of the role of the program manager in systems acquisition. His grasp of the cost-schedule-performance tradeoffs, his undiluted authority to make decisions, and his access to the highest authorities, are essential to the success of any program. Our experience in commercial practice is that there are only a few really outstanding individuals who make top-notch project managers. These men must be carefully chosen, nurtured, and motivated to accept the awesome responsibilities of the job.

4. Hardware competition should be maintained throughout the life of many major projects regardless of the type of contract, be it CPFF or FP type contracts. Competition is a forcing function that will cure many ills.

5. More emphasis must be given to prior performance and responsiveness to DoD's hardware needs, in the selection of contractors.

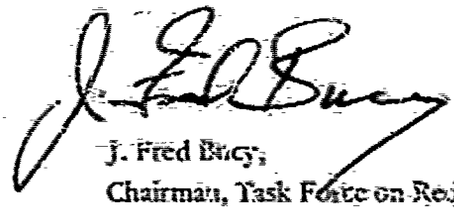
IN ESSENCE, COST REDUCTIONS AND "DESIGN-TO-COST" CANNOT NOW OVERCOME THE PRESSURES OF CONTRAVENING FORCES. AS LONG AS COST JUSTIFICATION EQUALS INCREASED PROFITS, AND PROGRAM MANAGERS LACK TRADE-OFF AUTHORITY, EVEN THE BEST IMPROVEMENTS ARE DOOMED.

The following quote of Arthur F. Burns is applicable to the plight of DoD:

> "It will take courage for the Congress and the Executive to deal with issues of structural forms in forthright fashion. The ground to be covered is difficult and enormous."

The Task Force supports the policies set forth in DoDD 5000.1 and urges its strong support and rapid widespread implementation. The compatibility of defining the need for change in defense system acquisitions in prior reports by other task forces suggests that substantial improvements can be made and that now is the time for action. The timing of this report is its essence. National priorities have changed, and the future defense system posture truly does depend upon cost effectiveness.

Let me conclude with this thought: Many of today's problems are the results of out-of-date solutions to yesterday's problems that no longer exist. Yet the directives and the laws linger on.



J. Fred Bucy,
Chairman, Task Force on Reducing
Costs of Defense Systems Acquisition

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Captain T. H. Ross, USN	ODDR&E, Task Force Secretary

CONTENTS

CONTENTS (Continued)

SUMMARY

The commercial approach of managing the design, development, production, and "life support" of a product to meet the marketplace value to the user – independent of "estimated cost" – is applicable to DoD procurement. A part of this general approach has been designated by DoD as "Design to Cost." But "Design to Cost" is the integrating element of the larger process, and cannot be implemented as an isolated management technique or control system.

This report outlines and recommends a few key techniques based upon successful commercial practice, that should find useful application to almost all DoD programs. A comprehensive management approach is necessary for their effectiveness. The strong inference is that a major change in DoD management of defense systems is required.

The principal decision areas of a commercial product program may be categorized as:

- Requirements and Cost Estimates
- Trade-offs
- Resource Allocation

Commercial Practice:

The first two decision areas, in commercial practice, are the responsibility of the program manager. He is expected continually to optimize the program as it progresses. The third area, Resource Allocation, is usually the responsibility of a higher level of management, since it implies a broader range of prerogatives, and balancing available resources among competing programs.

In industry, program requirements, including unit cost estimates, are usually developed by the program manager. They embody not only the end-user needs of today, but anticipate those of at least five years hence – as projected from the current state of technology, competitive strengths and weaknesses, and estimated value of the product, or market price. These requirements are described in brief, functional specifications, and are reviewed and approved by higher management for consistency with corporate goals. During execution, the program is frequently reviewed by higher management to measure its progress and to make appropriate adjustments in resource allocations.

The typical commercial program management team is small, cohesive, and highly competent. It usually includes an appropriate balance of advocates for cost, technology, and marketing. Their tenure is at least through a major program phase, e.g., conceptual phase through initial production. Communications are direct and quick, and decisions can be made on a timely basis. The personnel are highly motivated to realization of the project's economic success and customer acceptance,

which in turn provides a principal opportunity for individual growth. The requirements, which are essentially the product strategy, are continually reevaluated during the design phase in order to capitalize on new information. Throughout the product's life, cost reduction is a major objective, since the difference between unit price and cost (including amortized non-recurring cost) is the sole determinant of profit. Of equal importance is responsiveness to the customer, for he alone rewards the producer, through repeat business.

Defense Practice:

On the other hand, the DoD–defense-industry environment presents a strong contrast to commercial practice. Contractor earnings are limited by statute and regulation and are related to justified cost, not price. This focuses the contractor's emphasis on looking backward at costs already incurred, and justifying cost of future work, rather than looking forward to reducing costs of the program through design improvements and management efficiencies. Procurements are constrained by commitments for single year funding, with emphasis oriented to realization of the costs and performance goals for the particular phase, as apart from the long-range effects on subsequent production. Cost reduction leverage during the development phase, to achieve subsequent gains during production, is not usually exercised, since this can reduce the DoD contractor's revenue.

The requirements are established largely from operational and technical considerations, apart from and before the project team is organized, and the subsequent responsibility for reevaluation of these requirements by the program manager is not clearly defined. Also, program requirements are excessively specified and documented, adding burdensome layers of paperwork and management control.

The authority of the DoD program manager to make timely decisions is limited, particularly due to the long lines of communication and diffusion of responsibility between the program manager and the many "ilities" – those who control specifications, the procurement boards, and other audit and review agencies. Moreover, the program manager's tenure may be abbreviated due to rotational tours of duty that stress command responsibilities, rather than management achievement, for recognition and advancement. It is difficult for the program team and the "ilities" to share a common motivation and goal, and this accentuates delays in decision-making, thereby increasing cost.

Recommendations:

The implementation of the essence of commercial practice within this DoD–defense-industry environment requires a comprehensive change, rather than the selective implementation of a few isolated recommendations.

Principal recommendations are:

1. That the Program Manager be given full authority to make timely decisions on performance/cost trade-offs, and that he participate in establishing requirements.

2. That the program management team consist of highly competent individuals, whose tenure is oriented to completion of major program phases, and whose technical background is appropriate. That strong motivations and incentives for these personnel be developed, to counteract the tendency to follow the lines of least resistance.

3. That program requirements be balanced between performance and cost — and that their specification and documentation be made directly pertinent to the program.

4. That specifications be more nearly limited to "end-item" orientation, including performance, environment, and long-term warranty or service policy. That the thousands of detailed "how to do it" specifications be reduced, and, in many cases, eliminated. That, to achieve these ends, greater emphasis be placed on the test and evaluation of prototypes, and less on paper specifications.

5. That DoD's weapon systems acquisition policies be modified to place unit price in proper perspective, to provide a more direct incentive for cost reduction. This is not to suggest any single grand plan of "total project" pricing, but rather to focus attention on adequate unit pricing as an incentive to continual cost reduction.

6. That program requirements, particularly unit production costs, must be developed at the beginning, and reviewed or revised regularly, to assure that the relative value is still being attained.

7. That, for non-weapon procurement, a greater use of commercial products be made.

8. That competitive procurement of hardware be extended as long as possible, and to the greatest extent applicable to systems, subsystems, and components procurement. Competition is essential whether the contract is Fixed Price, Cost Plus Fixed Fee, or even an Incentive Contract. In such competition, increased weighting and emphasis should be given to the contractor's prior performance and responsiveness.

9. That the important role of Cost Plus Fixed Fee contracts should continue, for development and prototype contracts, where effective Fixed Price competition cannot be achieved without the addition of large contingency factors.

10. That, to provide an open environment in which these changes can take place, the hierarchy of DoD program management structures be realigned and simplified.

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To summarize the summary: Make all changes necessary to motivate contractors to reduce costs, rather than to justify them.

This study does not consider in detail the many existing DoD programs that are intended to increase cost awareness and accomplish cost reductions and savings. Such programs as value engineering, "should-cost," incentive contracting, production item breakouts for competitive procurement, and advanced production engineering, are of undoubted value. But for the most part, such programs have been applied mainly in the production phase to reduce cost that is not forced out during the conceptual, development, and design phases through competitive action. This study, rather, has been concerned with a management approach in which cost trade-offs are a continuing force throughout the program life, from initial conceptual planning through the entire production phase. That is, throughout the life cycle of DoD equipment. Cost reduction must become an integral element of program management, from the very beginning to the end of defense acquisition.

1. COST REDUCTION AS CONTINUING EFFORT

Finding:

Cost reduction should be a central continuing effort throughout the life of a product.

Commercial Practice:

The principal elements of commercial practice are:

Defined cost goals
Competition throughout program life
Competitive survival makes cost reduction a pervasive imperative of the commercial culture

The commercial practice of designing-to-cost begins with the development of an initial cost objective. These cost objectives are an integral part of the program's objectives, just as important as performance or end-use requirements. The real controlling cost objectives are the unit costs that must be realized during the production phases of the programs. While unit cost goals for the end of a design phase may be useful milestones, they cannot be considered as the program's cost objective. Commercial developments are undertaken wholly with the expectation of producing and marketing the product at a profit over some span of years. This is the sole criterion of success, and the cost objectives must be consistent with this definition.

The important ingredients of successful commercial programs are that the market requirements be predicted accurately, and that the cost analysis, when combined with the price the market will allow, provides a recurring gain on each unit produced. This gain typically starts early in production. To target development or design costs as the program's objective is inadequate and inconsistent with historical facts, because the continual development of new knowledge when properly applied can have significant leverage on subsequent production costs.

The development of cost objectives is made through direct contact and interchange of information between design engineering, manufacturing, purchasing, and other functions that will contribute to the program. Initial estimates are usually prepared by a small group of experienced and skilled individuals. Involvement of large groups is wasteful and time-consuming until after broad program parameters have been defined and detailed. Cost objectives, even if arbitrary, must be developed in sufficient detail, with responsibilities clearly defined, so that subsequent trade-offs or changes from these objectives can be identified and understood, and responsibility defined. Final decision-making is usually in the hands of one overall decision-maker.

In large organizations, the responsibility for compiling cost objectives and initiating timely reports comparing performance against objective generally resides with a Controller or Financial Control activity. Their responsibility is to identify cost problems in advance for their program management, rather than merely adding up the bill afterwards and justifying these costs.

At the time of program commitment, the competition is started. As soon as one commercial company commits to a definitive action, that announcement normally triggers action on the part of competitors. This competitive reaction will usually cause variations or adjustments in the product's development or production plan. These competitive adjustments may increase development costs, but the end product is substantially improved. Competition continues throughout the product's life, and is a forcing function to provide a better product at a lower price.

Discussion:

Consideration of costs should begin early in the conceptual phase of any weapons system — during the requirements process. In commercial practice, this is an inherent part of business planning; the elasticity of demand with price, and the price of competitive products, provide the natural bases for weighing the cost factor in arriving at requirements. In the DoD requirements process, these natural measures and weights for the economic factor do not exist; as a result, relatively little consideration of cost is made in arriving at military requirements.

It is true that the concept of continuing trade-offs between performance and cost has now been introduced into the DoD system acquisition process. However, to be most effective and to minimize wasted effort on the part of both DoD and its bidders and contractors, cost/performance trade-off decisions should be made as early as possible in the conceptual phase. Moreover, even when trade-off decisions cannot be made, an attempt should be made to establish trade-off rationale and criteria as an integral element of military requirements formulation. Such rationale and criteria would provide a basis for subsequent cost/performance trade-offs by the program manager and the contractor in later phases of system acquisition. Ordinarily such an approach would mean that no military requirement would be issued in final form until there had been two or three iterations (based on tentative or draft requirements) of exchanges between requirements agencies and development agencies, who would be assisted by contractor studies and proposals. The requirements writers would then have before them at least a preliminary evaluation of the way in which increments in required performance would influence total system costs.

The environment of DoD procurement has developed a number of practices that are counter to commercial practice. These include the limitation of single-year funding (with both its attendant delays and its emphasis on gaining budget approval annually), and single-source procurement of major weapon systems.

The former places emphasis on the development of cost targets for the impending phase, and, at times, the development of unrealistic or overly optimistic cost estimates to gain its approval from Congress as a budget line item. This fragmentation of a product's development and production phases produces pressures opposite to effective design-to-cost. The struggle to achieve a lower cost for a development budget often causes an adverse trade-off between development costs and subsequent

manufacturing cost. Further, the delays incurred in gaining budget approval for phases of the program cause significant increases in the contractor's overhead and indirect costs.

Without the development of specific and detailed production cost objectives, there is no effective counterpressure against the extreme emphasis on near-term cost objectives. Most DoD programs suffer throughout their lives from cost objectives that have been derived through pre-award negotiations, where an unrealistic balance of costs and scope and content of work to be performed has been committed to by the contractor to win the award. Moreover, in commercial practice, long-term warranties and service-life policies help assure concentration on long-term total cost rather than short-term costs.

In commercial practice, competition begins with program commitment. This competitive situation motivates the manufacturer directly to improve the quality of his product and to reduce the cost of his product, because the volume of follow-on orders depends essentially on the value and price of his product. In defense-based industry, the reverse of the commercial situation generally exists today. Competition occurs before program commitment and during formulation of requirements. There is less competition after program award because there is usually a single contractor and a single customer, and the competition from other programs is only indirect. The quality of the product, and to a degree the cost, is controlled essentially by the customer, who controls every element of the program through elaborate and costly management and audit techniques.

The ultimate price of a weapon system is a complex of many variables – not the least of which are the contract incentives and competition. The use of competition can, in many instances, be a more effective incentive than profit alone. Competition faces the contractor with potential loss of business and, therefore, organizational stability or continuity. This is often a stronger motivation than maximization of profit.

On the surface, competition extending beyond the initial procurement appears more expensive – but only if one accepts the premise that there is little difference between the performances of contractors, and that costs tend to normalize. Although this assumption tends to underlie most DoD procurement activities, the gains from constructive competition should be studied. Commercial practice demonstrates that a beneficial impact on design-to-cost is made if competition is extended over the program's life.

DoD is making a limited start in the use of competition in major defense systems, applying it to demonstrate system feasibility. Operational prototypes and "fly-before-buy" represent highly effective and positive means of achieving beneficial competition between technical approaches, and can be cost effective if properly incorporated into the total program plan.

Competitive prototypes are particularly beneficial when performance and cost objectives result in significant differences in design concepts, as demonstrated by the AWACS Program. When compared

with other noncompetitive subcontracts, Hughes and Westinghouse were both motivated to perform in a superior manner. For example, both companies furnished the highest quality personnel resources available within their company and within industry. This included technical, management, and flight test personnel. In fact, Hughes continued to furnish highly qualified personnel even though the Hughes subcontract exceeded ceiling, and a significant part of this cost was at their expense.

Further insight is provided by the following paragraphs, taken directly from Boeing's recommendation regarding the subcontractor award fee:

> "Both companies vigorously pursued the incorporation of modification to their equipments and designs which would allow them to achieve the peak performance possible during the flight test time frame available. Improvements were incorporated into both systems in weeks, which in a normal development cycle would have taken months. Hughes greatly increased the dynamic range of their system and incorporated the HIPER Mode. These changes permitted satisfactory operation in the large main beam clutter encountered in the Northwest, and accommodated the large numbers of fast-moving cars in the test areas. Westinghouse incorporated a new STALO with increased stability and changed their PRF to cope with the large main beam clutter and altitude line difficulties. The Air Force benefited greatly from these and other modifications and will have a much better DDT&E system because of these efforts on the part of the two companies."

> "To summarize, in AWACS the "Fly-Before-Buy" competition was more than worth the cost. Without the stimulus of the competitive environment, we feel it would have been impossible to motivate either contractor to the level achieved in the breadboard Fly-off. Program estimates range up to 100 million more dollars for 25% less performance if we had gone with only one radar contractor."

Commercial aircraft experience indicates that a significant magnification of costs is generated by unresolved technical problems that impact production during the rapid buildup of production rates. Cost research into past and current program experience stimulated the development of modeling techniques that compare the cost impact of such program variables as the volume of engineering changes, production rate, out-of-sequence modification, new model (derivative) introduction, and skill availability. It was determined that: (a) if a program could be structured that would minimize technical risk, resulting in the elimination of 25% of the critical changes, and (b) the production schedule could be structured both to minimize out-of-sequence work resulting from engineering changes and to optimize manpower buildup; then, a reduction of 25% to 35% of the costs of a 200-aircraft program was attainable. If, to minimize the technical risk, prototype or preproduction airplanes were required, a 15% to 25% reduction in total program costs could still be anticipated.

Recommendations:

1. That cost factors be introduced as early in the weapon system conceptual design and planning phases as possible, and that formal requirements in final form be issued only after several iterations of cost/performance estimates between the developing agency and the requirements-formulating agency. A financial function assigned to the requirements agency should be directly involved in the task of formulating these objectives.

2. That unit production cost estimates must be maintained throughout the development cycle. Program managers should receive stronger financial support throughout the life of the program, and this financial function must be responsible for analyzing unit cost trade-offs, and be the strong advocates on the program manager's team for realization of unit cost goals.

3. That effective hardware competition be maintained over an extended period of program development and production, as long as possible, and to the extent applicable to systems, subsystems, and components. The size and the production potential of a program should determine the type of competition.

a) Programs intended to be R&D only and never go into production, should rely on the initial proposal competition.

b) Programs with a reasonable production quantity over a relatively short time, might utilize the initial proposal competition to select two or more vendors to carry out the prototype program. Selection of the production contractor can then be based on a comparative evaluation of performance as well as a production-cost competition based on the developed designs.

c) Programs with production extending over many years can use the same approach during the prototype phase, but should consider extending the competition into the production phase. Such competition might take one of two forms:

1) Competitive production of both designs

2) Second sourcing of the superior design

d) Care should be taken before initiating open production competition, even in the cases where extremely high production quantities are involved, when the result might eliminate the ongoing technical support needed for the future continued success of the program. Although in the past this approach has, in some instances, resulted in apparently dramatic cost reductions, a representative cross section of such cases should be studied to determine the problems of qualification of new

vendors, which may add indirect costs because of incomplete production packages, as well as the impact on the continuing existence of the development organization.

4. That, to further stimulate "design-to-cost" solutions to new weapons programs, the use of dual, competing program offices during the initial conceptual phase and even the technical feasibility phase, should be considered. Such duality, of course, must be limited to special cases that appear to warrant the cost of competing offices and the added management burden of controlling them.

2. COMMERCIAL PRODUCERS REWARDED FOR COST REDUCTION

Finding:

Commercial producers are directly rewarded for reductions in cost, by increased profit margins.

Commercial Practice:

The principal elements of commercial practice are:

Production-unit pricing allows reductions in cost to create improved profit margins.

Users reward producers who achieve high quality at low cost, through repeat business.

In commercial practice, a producer enters the program not because he has a chance of making money on the prototypes or early production units, but because he has a belief in the product's long-term demand. The products are procured on a unit price basis, and the manufacturer is directly rewarded for reductions in cost by earning a greater profit margin, or gaining an increased market share, or both.

The customer usually contracts for production articles at an agreed-upon price, and the necessary development is the responsibility of the manufacturer. For this reason, the total development program is managed under the incentive of increasing the quality and reducing the cost of the production article. This incentive is realistic and achieveable if the manufacturer has entered the right market with realistic cost estimates. The manufacturer has considerable freedom to make cost-effective changes in the development program before production.

Cost reductions are often measured in terms of profit leverage, e.g., for a product targeted at a 10% margin, a 2-3% cost reduction could leverage profit margins by 20-30%. This perspective focuses key management attention on implementation of small, incremental cost reductions.

For major commercial products, the manufacturer's financial success is highly dependent on responsiveness to his customers. Excellent customer satisfaction is of paramount importance in follow-on procurements. Thus, the "real" user benefits from manufacturer responsiveness, and he alone rewards with the follow-on procurements.

Discussion:

In both commercial and defense-based industry, the fundamental and driving manufacturing objective is competitive survival. This primary objective, in turn, motivates the manufacturer to seek

greater market penetration, volume of business, customer satisfaction, product quality, production continuity, and other conditions which lead to greater immediate and future earnings.

Although the profit motive is quite similar for commercial and defense-based industry, the means by which this motive is satisfied are different. The differences relate to the market characteristics (a single large customer), the complex DoD weapon system acquisition process, and the fact that earnings are controlled by the customer and related to the manufacturer's justified cost.

DoD IS THE ONLY CUSTOMER CONCERNED WITH THE CONTRACTOR'S COST, RATHER THAN HIS PRICE. AS A RESULT, INDUSTRY CONCENTRATES ON JUSTIFYING COSTS, RATHER THAN REDUCING COSTS.

The entire DoD acquisition process, starting with the initial establishment of requirements within DoD, and proceeding on through the successive phases of Request for Proposal, Proposal Evaluation and Source Selection, and Program Implementation, is geared and directed toward meeting the cost goals or targets which have been established in each phase. The emphasis is to meet the established goal even though the proper and realistic cost may in fact turn out to be less than what the successive phases of the acquisition process indicated the project "should cost."

An example is the carefully developed (and DoD accepted) "Learning Curve," which is often misused to discipline cost rather than to minimize it. Too often, in the case of aircraft, a historical man-hour-per-pound learning-curve slope is employed. If the historical slope is 85%, say, then all planning is geared to the 85% objective, and accomplishment of this objective is considered a triumph -- even if the project could easily have been targeted at a much steeper slope. Establishing the optimum slope is a science in itself, but in commercial practice, considerably steeper slopes may be experienced for a particular phase or period of time. Maintaining steep learning curves demands continuing cost-reduction effort throughout the production program.

In defense-based practices, once the program award has been made, the manufacturer's prime motivation is to execute the highly defined development program. Flexibility is destroyed. This focus on development tends to deemphasize the production program, and in particular, deemphasizes changes which would be cost-effective in production for articles not yet on order and negotiated. Because the initial program award is highly competitive, the contractor is at times motivated toward marginal guarantees. He may be required to commit to ceiling prices on production articles before sufficient knowledge is available to determine that these ceilings are realistic. And the development tends to concentrate on performance, neglecting manufacturability. All of these characteristics tend to detract from the incentive to reduce costs of follow-on production articles during the development program.

The DoD procurement policy of first establishing the cost base in negotiation, and then allowing a profit or incentive as a percentage of this cost, is self-defeating in motivating timely cost-reductions.

Commercial programs normally do not make profits during the early periods, when both technical risk and investments are high. However, the risk reduces and the return on the investment increases as the program matures. This is the opposite of the government contracting approach. A contractor is allowed a higher percent profit for the high-risk areas which are normally in the early developmental and startup periods, but loses it as the risks decrease during the follow-on production.

The obvious result is to discourage all cost reduction. In absolute dollars, a higher percentage of the smaller number (R&D) is often less than a lower percentage of the larger number (production cost). In such cases the DoD contractor makes more absolute dollars by not reducing costs.

It is the progression toward continued constant or even lower percent profit that thwarts the present methods of cost-reduction motivation. In fact, cost reductions and excellent contract cost performance presently establish the basis for lower profit potential per production unit, on each follow-on procurement. In addition, large cost reductions adversely impact the contractor's overhead rate, force termination of hard-to-recapture skills, cause adverse community reactions, etc., if the contractor does not have another project that needs the skills the cost reductions eliminate.

So the contractor makes money not by reducing his overhead, but by justifying it – and not only does he make money, he preserves his organization as well.

Recommendations:

The recommendations for this finding impinge on major policies or Congressional directives to DoD, and consequently require further development. At first reading, they may appear to have only indirect bearing on the purpose of this report. Actually, these factors are among the most fundamental reasons for the ever-increasing costs of defense systems.

1. That a stronger coupling be made between negotiation, evaluation, and approval of development costs and projected program requirements. This may include:

   a) A closer coupling of the procurement agency and the organization that establishes the technical specifications, to realize a better balance in negotiations, between the program's longer-range objectives and the current negotiation goals.

   b) Granting contractors greater operating flexibility and opportunity to achieve superior earnings, through design and production of high-quality systems at low cost.

2. That new approaches to follow-on production contracts be developed, oriented to the development of unit prices as a basis for negotiations, permitting a resultant increase in profit percentage as costs are reduced. If a company manages to offer a product at a lower price, they deserve to make higher profits. Protection of the public's interest is already provided by the Renegotiation Act.

3. That greater emphasis and weighting in source selection should, particularly for subsystem and component equipments, be placed on the past performance record of the manufacturer in meeting prior requirements, providing field service and support, and achieving overall program cost effectiveness, as well as on his present capability to maintain a high level of performance.

3. COMMERCIAL PERSONNEL REWARDED FOR COST REDUCTION

Finding:

Authority for performance-versus-cost trade-offs is well defined in successful commercial programs.

Commercial Practice:

The principal elements are:

Planning is iterative.
The program manager has adequate authority to capitalize on new inputs.

Each element of the program plan covering performance, cost, and schedule is developed in an iterative process until it can be merged compatibly with the other elements to form a realistic objective. One of the pitfalls associated with a product development program is the assumption that, once approved, the plan is unalterable. In fact, the opposite is more often true. The program's plan must be iterative, but under tight control. The initial plans are only as good as the initial inputs available at time of preparation.

In large corporations, a mix of overall centralization in planning, and decentralization in execution, is often most effective. Such a structure sets objectives for the important programs and resources (often arbitrarily), and then allows considerable discretion and creativity to the program managers in getting there. In the pre-program phase, considerable trading takes place between cost and performance as a product is developed to compete in the particular market segment identified. This same process continues subsequent to program approval, since inevitably a large number of unknowns remain to be resolved through more detailed engineering, production prototype testing, detailed manufacturing and assembly processing, and new market requirements. To regard stated program requirements as "untouchable" at or after program approval would be to miss a major portion of the trade-off opportunities . . . because the knowledge necessary to recognize them does not exist at the time of initial approval.

In industry, the use of program management for major programs, coupled with tight cost objectives for each organization to provide incentive to seek out profitable cost/benefit trade-offs (as well as trade-offs between cost and weight, fixed and variable costs, material for labor, to name only a few) has proved most effective.

In industry, the typical approach on major programs is to assemble an interdisciplinary team, with well-defined leadership (and similarly well-defined authority and responsibility). The program leader is usually given the authority to make cost/performance trade-offs, to the extent that they do not importantly alter the overall program. He is responsible only to senior management.

The authority and responsibility of the program leader are clearly defined, as are the overall product performance specifications, within these, he has considerable latitude to alter design specifications to accomplish the program at minimum cost. When a major trade-off is proposed, it is the responsibility of the program leader to present the proposal, to be reviewed and concurred-in by the higher-ranking managers who originally approved the program.

In most cases, it is effective to "dedicate" people from the various functional organizations involved (QC, Purchasing, IE, etc.) to pinpoint responsibility to individuals, and to provide a work force at the command of the program leader. These individuals are assumed to speak for the organization they represent on the program; this alone considerably simplifies and shortens the complex job of coordination and communication. While they may have other duties, it is clearly understood that as "dedicated" personnel, the program requirements come first. The more flexible and rapidly reacting the program management, the better and more numerous the cost/benefit trade-offs . . . because the time span between having knowledge sufficient to make the decision, and the time when changes must be made firm in order to make the production deadline, is surprisingly short.

Programs are typically controlled by monthly reporting against the detailed cost objectives to top management, with each of the responsible organizations reviewing its own performance. In this way, the authority of the program manager is reinforced by the review of his senior management . . . helping to avoid the awkward problem of his being outranked by senior members of supporting organizations, who may not agree with his decisions.

Often, in addition to these general product review meetings, on each major program a series of monthly meetings is held as part of a company's overall cost-control program. These programs are usually controlled in great detail, with objectives by part, and by element of cost . . . the rationale being that where designs are changing the most, the greatest opportunity exists for making trade-offs, and the greatest need for information exists about the effects of new designs on other related systems. This process brings to bear the accumulating knowledge of the entire engineering, manufacturing, planning, and financial organizations, on the tight cost objectives that have been set for them.

As overall analytical benchmarks to aid in the control process, all changes from the existing design level of the product are scrutinized. Because it obviously costs money to change, the initial question is "why change at all?," rather than carry over an existing part or series of parts. When a changed part is justified as a functional improvement, that improvement is required to be quantified, and its desirability is weighed against the identified costs in one of the product review meetings discussed earlier. If accepted, it is included in the program, but really only in the light of the current status of the program versus objective. The flexibility is maintained to revisit any of these improvements if required to achieve the established cost targets.

In commercial control and analytical systems, the controller's office (including a sizeable group of experienced cost estimators) normally plays a key role. The objective is to surface to the appropriate level of management, that a trade-off opportunity exists, along with the data necessary to make an intelligent decision.

Discussion:

In contrast to commercial practice, it appears that the circumstances of program management in DoD often conspire to prevent trade-offs after requirements are set. The inadequate authority of program managers, frequent lack of "dedicated" high-level people from the participating organizations, extremely detailed requirements specifications which require time-consuming negotiation to alter, and lack of incentive within the organizations that possess the necessary knowledge to suggest trade-offs between costs and requirements, all appear to contribute to the problem. The end result is that all too often the best opportunities are not known until well after the decision date for incorporating them has passed — if they become known at all.

The most apparent difference between the governmental and industrial program manager appears to be the industrial manager's freedom to act without lengthy pre-coordination, especially on a purely commercial project. Within industry, the pressure of continuing expenditures against committed schedule milestones generates the urgency for prompt and decisive redirection in problem areas. The governmental program manager is seldom able to match his industrial counterpart in reaction to the unforeseen and may not be able to get the necessary approval for proposed redirections in time to avoid unnecessary over-runs or schedule slides. In defense of the DoD program manager, however, we must admit that industry runs free of the heavy staffing DoD requires to defend itself against attack from the socio-political environment.

The government program manager has as his major responsibilities the establishment of program statements of work based upon user requirements, and the determination that the contractor is meeting these requirements. The program manager must monitor the contractor's performance in such a way that he can justify to the buyer that the program is meeting objectives and should be continued. While he performs these responsibilities, he must also develop a common interest with the contractor, in the pursuit of cost reductions. The heavy burden of verifying performance, however, often precludes any emphasis on cost reduction.

The contractor, while vitally interested in program continuity, must be primarily concerned with developing designs, hardware, and systems that meet the requirements. And problems almost always appear between the government program manager and the contractor when it comes to determining "how much" is enough to determine that a requirement has been met. How much margin, testing, documentation, etc.? Since the government program manager has more justifying to do, more standards and specifications to meet, (and more people with the task of seeing that

"all the squares are filled in"), he generally will want to have more "activity" before a decision is made, than the contractor alone would require. The result is that unnecessary time and effort are often required by the government over that absolutely essential to move forward with the program.

In industry, periodic reports and documentation are "exploded" to give high visibility to critical problems. As they are completed, this documentation is collapsed so that the project manager is not overburdened with excessive documentation, instead, the reports he receives focus his attention on key problems.

In contrast, many government procuring activities continue to feel that the only way to control project costs is to lay on many paperwork controls. All of the technical and management-oriented "ilities" get their requirements into the RFP and in to the subsequent contract work statement. While some of these management requirements are of course necessary and justified, many of them also tend to detract from the productiveness of the overall effort. Despite numerous policy pronouncements to the contrary, it often appears that, as the R&D content of a contract increases, the requirement for paperwork to manage, report, and control the effort also goes up, instead of down.

In DoD, the procurement activity and the local "ilities" are not directly coupled to the program manager or the user. The goal of establishing and realizing a common objective is not attainable. On the other hand, in industry, procurement and its related vendor activities are completely subservient to operating management, and share in common objectives for the program.

Recommendations:

1. That an appropriate forum for evaluating cost/performance trade-offs, at varying levels of authority depending on the importance of the trade-off, be established. It is recommended that this be part of a regular monthly review established for each major program.

2. That government Program Managers be given sufficient authority to go with their responsibility, to integrate requirements from all commands, to approve trades between conflicting requirements to optimize the system, and to make timely decisions.

3. That all changes necessary be made, to involve the financial functions deeply in the task of formulating objectives, projecting the actual costs likely to be incurred versus these objectives, and presenting the opportunities for overall cost/performance trade-offs, as they are developed.

4. That the program manager's office be motivated to share a common interest with the contractor, in the timely pursuit of cost trade-offs. This must be accomplished while preserving the program manager's responsibility to monitor and assure contractor performance.

Long-Term Recommendations:

1. That the project decision-making role (or "non-decision" role), of the procurement and inspection agencies and the "ilities," be made clearly subordinate to the program manager. These agencies can perform a vital function by providing "checks and balances" for review management, but should not be allowed to discourage, thwart or delay timely decisions by the program manager.

2. That DoD reduce considerably the tremendous scheduling and documentary requirements established by "ilities," and applied to contracts. Instead, these controls should be delegated to the program manager to be used during phases where required, and then deleted as quickly as they no longer serve a direct role in controlling the program.

4. PERFORMANCE VS. COST TRADE-OFF AUTHORITY

Finding:

Commercial project personnel are motivated to reduce costs.

Commercial Practice:

The principal elements are:

Clearly defined and detailed objectives
Top management commitment
Timely reviews and trade-offs
Incentive motivation

In non-defense industry, there are several sets of motivations that operate as incentives toward the most efficient design and manufacturing process. These encourage cost-effective trade-offs to modify initial product specifications for important cost or performance benefits. First, the overall motivation of the company itself is toward this end; each dollar of cost reduced or avoided is another dollar freed to develop new products, and the desirability of all projects requiring resources can be ranked, based on the expected return earned on the investment required. Competition also motivates the company; if it is not agile and resourceful enough to match its competitors, it will ultimately find its existence in jeopardy through being overpriced or working with an inadequate profit margin.

Even in industry, however, there are managers who believe the purpose of having a budget is to spend it, for if it is not spent it will be taken away . . . not only for that year, but for all succeeding years as well. Individual and organizational programs and systems have had to be developed to supplement and "flesh out" the overall corporate profit and competitive motives. These are required because in a large organization, overall objectives that are quite clear to the top echelon rapidly become diffuse and secondary when compared with individual objectives such as growth, extension of influence, maintenance of existing prerogatives and spending levels, change for the sake of change, or the pursuit of bigger and better designs even though present designs are adequate.

The job of motivating the individual lies in creating an environment that channels his efforts and the organization's, towards common objectives and goals. In such environment, the individuals of the project team participate in the development of its goals, and review their progress with the same management that understood and approved the program's objective.

Thus, the project team understands the goals, communications are quick, and there is little confusion regarding direction once a decision has been reached. These actions do provide motivation for individuals in the form of recognition, timely action on ideas, and participation on a winning team as goals are realized.

The job of motivating individuals goes one step further. A key incentive is the effect that attaining assigned financial objectives has on promotional opportunity and on individual financial reward.

In this way, without delegating too widely the important overall performance requirements, industry is able to stimulate the various line and staff functions to discover and initiate cost/benefit trade-offs.

For the program to be fully effective, line management must be committed to meeting the plans and achieving the projected financial results. The best control system will be ineffective without good people given clear responsibility for results, good motivation at all levels to innovate, and high-level commitment and review.

Discussion:

The success of industry in stimulating cost/benefit trade-offs really lies in its ability to construct an environment that channels organizational and individual efforts toward these trade-offs through a system of objectives and rewards. Competitive survival serves as the backdrop and as the motivator for the top policy makers; gives an equally compelling motivator at DoD (a fixed spending budget and the threat of "defense bankruptcy"), these same systems should be workable for defense programs. An additional motivation for DoD would be the ability to apply cost savings to unfunded programs, within the constraints of Congressional review and approval.

One of the principal inhibitors to motivation of personnel in defense-based industry is the long lines of communications, with their attendant delays and misinformation, and the diffusion of responsibility among a hierarchy of commands and "ilities."

The present mode of DoD operation contributes to misinterpretation and misdirection in the implementation of DoD defense system acquisition policies and directives. Each service has a degree of deviation or presents a different phase delay in implementation of these policies, that creates non-uniformity and sincere lack of understanding of the basic intent of new policies by various procurement, contractual, and auditing agencies.

The delay to some extent may be unavoidable in view of the large and many geographical areas to be covered by a comparatively limited number of training personnel. Further, their training sessions are often aimed primarily at district working levels with little or no special effort being given to the indoctrination and training of district management levels in the basic thinking that went into the DoD policy at the outset. This has resulted, at times, in the district management levels contravening and subverting the fundamental intentions of a DoD policy through implementation according to their personal opinions and beliefs. This has been true more often in contracting and accounting areas, than in project and technical areas.

This problem in communications and education can be alleviated to a great extent by the increased employment of highly effective communications media – for example, videotape.

Yet there is concern that these policy differences and delays reflect deeper and more basic problems. Applying commercial practices to defense system acquisition will require profound changes in existing organization, methodology, and culture.

The complex and multilayered defense systems acquisition hierarchy must be reorganized in the direction of simplicity. Such reorganization must facilitate a closer coupling among the using command, the program office, the procurement agencies, and the functional "titles." Only through adequate coupling can common objectives be understood and shared, so that timely iterations of cost/performance trade-offs can be made. Too often the contracting agency tries to force the contractor to meet the initial requirements since he has him "hooked" by an ironclad contract. A more successful approach would be to encourage timely cost/performance trade-offs.

A major organizational change could have a beneficial impact in the motivation of project personnel. Aside from improving communications and providing a basis for more timely decisions, it would provide a means to change management personnel who have been "too long in the job." Experience indicates that it is almost impossible for dedicated long-time public servants to adapt and to accept new concepts.

The inputs from DoD cost advocates must be given equal weighting with technology and user (performance) advocates in both definition of initial requirements and program execution. Too often, efforts to control costs have been subordinated by DoD management's desire and belief that equipment perfection can be obtained at reduced cost by squeezing the contractor instead of making cost decisions affecting performance within their own organization.

The diversity in implementation of DoD policy is also evident in the application of recognition and rewards for project and support personnel. A widespread award and recognition system for successful efforts to reduce costs in defense systems should be implemented, with suitable publicity given to top performers. On the other hand, a penalty system, other than a GAO investigation, is also needed. Whether or not effective penalties can be created under Civil Service restrictions is questionable, but all possibilities must be explored.

As currently established, the government procurement organization does not make sufficient provision for recognition of a significant accomplishment on the part of a procurement officer, leading to adoption of project changes which result in substantial contract cost savings or which ensure the contractor's receiving a reasonable earned profit. Contractor personnel commonly receive "bonus" or "incentive" awards for such accomplishments. Similar incentives, though technically available and used effectively in a few scattered cases, are not widely used to motivate government employees.

Recommendations:

The recommendations of the other sections of this report also directly impact this area. More clearly defined authority for program managers and shortened lines of communication would, in themselves, considerably strengthen motivation. Along with this there needs to be clear evidence of involvement, understanding, and commitment of high-level management to the program's objectives.

1. That DoD make better use of modern communication and training systems to provide fast and uniform fan-out of information regarding weapon procurement policy, rather than rely solely upon the issuance of directives.

These should include the following:

a) Centralized information or training sessions for key personnel, particularly those geographically removed from Washington.

b) Widespread use of the newer communications media. Commercial practice has proven that films and videotape are an ideal medium where conceptual material must be communicated. It is a highly cost-effective approach. Upper echelons can be sure that all designated personnel have at least been exposed to new policy, whereas we can never be quite sure whether people have even read a document.

2. That recognition awards, for excellence in design-to-cost by individuals within DoD, and consistent with Civil Service practice, be developed and properly promoted and publicized.

Long-Range Recommendation:

The direction and motivation of the broad and large personnel base of DoD to "design-to-cost" goals requires essentially a change in "culture" of weapon system procurement. It demands clearly defined goals, common motivation toward these goals, and a timely response to changing data. The present orientation and motivation of DoD's "lities" and procurement agencies often obstruct progress toward these goals.

To change this existing "culture," significant changes in organization and staffing may be required:

1) We recommend that DoD realign and simplify its hierarchy of management levels and controls for weapon systems procurement. In so doing, some of the layers of district or field offices could be abolished, allowing more direct communication with DoD headquarters.

2) That concurrently (and earlier, if possible) reassignment of personnel be vigorously pursued in order to bring an open viewpoint to the implementation of new policies.

3) That cost-conscious financial personnel in DoD be made responsive to program managers, and that their role be strengthened to properly balance cost development and execution with technical excellence.

4) That further development of rewards and penalties within the Civil Service system be explored and studied.

5) That budgetary procedures be pursued that will allow cost savings realized on one program to be retained by DoD and applied to new and needed programs which are unfunded. This may take the form of a budgetary pool that requires Congressional review and approval before reassignment.

5. PROJECT AUTHORITY CONCENTRATION

Finding:

Project authority should be vested in a relatively small number of people who are highly skilled and experienced.

Commercial Practice:

The principal elements are:

Management team is relatively small.
Communication is simplified and quick.

The management team in commercial industry is usually a small group of people who are highly skilled and experienced in the performance and operation of the project. Primary authority is vested in a project manager who reports only to company management. This close communication, with few layers, results in a smooth-running project and the satisfaction of the customer. The project manager and his key personnel are responsible for: including any innovations that would be beneficial to the program, motivating program personnel, keeping customers informed of new improvements and problem areas, and maintaining control of the program until its successful completion.

Frequent and direct communication with customers alleviates many problems, especially during the early stages of the project when design, materials, methods, and applications are of prime importance. Project management demonstrates the product to the customer, who approves or rejects it at several stages in its development. Upon the product's approval by the customer, it enters the production phase and continues on its path to completion. Relatively little documentation is required for the operation of the project, except for those documents that are necessary for guidance in the design and operation of the end product. This allows the project manager and his team considerable freedom to produce "best-performance-for-the-price," for the customer.

Discussion:

In direct contrast, project authority in DoD is based primarily on documentation, and only secondarily on a project manager and many assigned project personnel. Unfortunately, DoD personnel often have little experience in the area of the assigned project, so they have little choice but to depend heavily upon the documentation. Dependence of DoD personnel on documentation frequently leads to problems so far as the contractor is concerned, because he must adhere strictly to that documentation and may not deviate from it, as he can with commercial contracts. DoD project

personnel could be much more productive if they were permitted to rely upon the commercial contractor's abilities and recommendations concerning their product's development and production.

The principal evils resulting from "management by document" are rigidity and overstaffing – not only in project offices but in all the related "ilities."

There are cases where the government's project management organization is staffed at a level as high as one "customer" for each two "contractor" personnel on the total program. In addition to the other obvious complications of such a manning ratio, it costs the contract significant time and money just to maintain the interfaces which result from such density of management.

The FAA provides a successful example of how a government agency has been able to rely on industry's technical competence to avoid exorbitant governmental costs for duplication of the technical and inspection tasks which ascertain commercial aircraft's safety, airworthiness, and operational integrity. By relinquishing most apparent controls, the FAA achieves real controls.

Legislation enacted in 1950 authorized the FAA (then CAA) to delegate to qualified private persons, including employees of aircraft manufacturers, certain functions relating to the examination, inspection, testing, and issuance of certificates. This delegated system results in a substantial cost savings for the customer because fewer employees are required. It also results in substantial time savings to the manufacturer because the appropriate designees are readily available and well acquainted with the specific technical subject.

Two categories of designated representatives are used in the development of new aircraft:

1) Designated Engineering Representatives (DERs). A DER is authorized to approve engineering information and data within the limits of his designated field specialty, whenever he determines that the information and data comply with the applicable regulations.

2) Designated Manufacturing Inspection Representatives (DMIRs). Under the surveillance of FAA inspectors, a DMIR is authorized to inspect and review facilities, systems, and methods, to ensure that they comply with approved FAA requirements; to perform specific inspections of manufactured components and/or assemblies to verify conformity with approved design; to perform any other inspections necessary to determine whether prototype and production articles are airworthy and safe for operation; and to issue airworthiness and export certificates for aircraft that conform to approved type design.

The appointment process and functions of designees are broadly described as follows:

The aircraft manufacturer nominates qualified employees for FAA designation as DERs or DMIRs. Each of these employees must be a specialist in his field or fields and have intimate knowledge of FARs and FAA-type certification procedures.

The FAA reviews the qualifications of all personnel nominated by the manufacturer and appoints qualified persons to serve as FAA designees in specific fields. These appointments are effective for one year and may be renewed for additional periods of one year.

DERs and DMIRs (in cooperation with the manufacturer's Airworthiness staff in the case of DERs) review and approve data, and monitor design and fabrication for compliance with civil airworthiness standards within the limits prescribed by, and under the general supervision of, the FAA.

Our purpose in reviewing the FAA's approach is not to suggest the broad-scale application of FAA policies to DoD procurement, but rather to suggest a methodology of proven effectiveness. The FAA experience illustrates a successful method for achieving quality assurance without voluminous specifications and multitudes of people.

Recommendations:

1. That DoD revise their typical project management structure so that a small but highly skilled and experienced group of people, rather than a team of lawyers, runs the show.

2. That DoD select a pilot program in which military aircraft airworthiness and quality assurance is administered in a manner similar to that employed by the FAA. Consideration should be given to making a transport-type aircraft the test subject.

3. That the program manager review and rate the performance of all DoD persons - both military and civilian - assigned to the program. This should be done at least once a year, and the report should be included in the individual's personnel file.

Long-Term Recommendation:

1. That DoD delegate, where appropriate, many functions of review, testing, and approval to properly qualified and certified contractor employees.

6. CONTINUITY ESSENTIAL

Finding:

Continuity in both project management and project tasks is essential.

Commercial Practice:

The principal elements are:

Continuity in management.
Opportunity for individual growth.

A program manager in commercial business typically continues in that position so long as he directs the program to company management's satisfaction. He is rewarded with increased responsibility and salary within his program. His personal success and future depend on his ability to direct the program intelligently, to motivate his personnel, to control excessive expenditures, and to produce a high-quality product at the least cost feasible while providing an adequate profit for his company. His abilities become known as his product advances through the marketplace, actual sales and sales projections show considerable up-trends, personnel staff increases or mechanization become the better way to advance production, and technical innovations by personnel aid in the cost reduction of the product in the marketplace.

Company management affords a successful manager the opportunity of added responsibility where his proven capabilities can be exercised to the fullest extent possible. His successor is usually an outstanding member of his staff who has progressed with the program from its inception through production and established position in industry. Therefore the program will continue with few disturbances because of the continuity of leadership provided the program's personnel during its various stages of development.

When the successful program manager accepts his new challenge, because of his past effectiveness some personnel will transfer with him to the new program, thus affording all the advantages of development and production experience, technical abilities and knowledge that may be adaptable to the new program's product. The continued progress of the program, alertness and motivation of personnel, cooperation among personnel, and general cohesiveness of the entire program reflects a program manager's abilities and provides an excellent day-to-day evaluation of his performance.

Discussion:

DoD program managers are rotated according to duty cycles that are not often coordinated with major phases of their programs. While it is unrealistic to expect that a PM should remain with

a long program throughout its eight- or ten-year life, it is reasonable to make assignments that coincide with major phases of the program. It would be advantageous, for example, to be assured that the same PM will head a program from beginning to end of its development phase, or throughout its production phase.

The immensity of the DoD project environment, with project offices buried in huge parochial support and operational functions, has institutionalized a highly complex management approach that is interrupted by a faulty personnel rotation and promotion cycle. Acceptance of this management discontinuity is apparently based on the assumption that management is the application of generalized techniques rather than the utilization of specific knowledge; this is the principal difference between the DoD approach to project management and that of commercial industry. Because the DoD management approach fails to provide project management continuity through people – the one absolutely essential integrating influence – various substitutes have been tried: 1) over-detailed and iron-clad initial specifications, 2) elaborate cost-reporting schemes, 3) complex systems engineering procedures, 4) extensive computer-aided statusing applications, 5) overwhelming documentation and data requirements, and 6) permanent staff-type committee/boards. It might be concluded that the pattern of forced interruption is a matter of government policy, obscuring the performance history of DoD program management.

No complex project organization can achieve or maintain efficiency in structure or operation by having a complete change-over in its leadership at all levels every few years. Good project management must have built into its very structure skilled personnel with project dedication and the organization must give them the stability and growth rewards to assure continuity in assessing cost trade-offs over the total program rather than segregated tasks.

Assignment on such a "phase by-phase" basis would also facilitate finding PMs with unique competence to handle a particular phase. It is much easier to find a production specialist, for example, than a development-prototyping-production specialist.

The competence, background, and experience of the PM is a vital factor in the success of a program. Commercial practice is to select a program manager from the broadest possible list of candidates, with great emphasis placed on "track records," technical backgrounds, effectiveness, and ability to withstand external pressures. A great deal of high-level effort is devoted to finding the right man for the job. Consideration of candidates is not always limited to a single discipline or a single company, in some cases, program managers are sought outside the company and even outside the industry.

Care is also exercised to ensure that the calibre of support personnel is maintained at a high level during the vital latter stages of a program.

The managerial problems posed by the DoD arise in good part because its project management corps must take its place within a strict military hierarchy which more often punishes than rewards innovation from the lower ranks. The objective of this system, military efficiency, cannot be easily measured in peacetime and therefore the managers cannot be suitably rewarded. The hierarchical structure of the military services is necessary to discipline and to coordinate control of large numbers of men, but it serves to stifle innovations, initiative, and risk taking.

The government's planned interruption and cyclic discontinuity of program management is one of the most deeply engrained sources of failure in the management system; this government practice directly contradicts the fundamental practice followed by industry. The other basic source of managerial failure is the misconception that "any good general manager" can successfully manage even a highly technical program.

Recommendations:

1. That increased emphasis be placed on the selection of PMs and key personnel, based on their proven excellence and appropriate technical backgrounds. The significance of assignments for military personnel should be re-ranked so that management of a major program is recognized as a career advancement.

2 That these searches for key technical executive talent extend beyond the military, to include both non-military government executives, and industrial executives who have had experience in government.

3. That the tenure of key DoD program people be increased, at least to coincide with the beginning and end of major phases of a program.

4. That the quality of project technical support not be allowed to deteriorate after the initial development phase, but be continued through to production or completion.

5. That an environment of growth, promotion, and pay increases within the same project management assignment, be provided – and that a project manager not be penalized for remaining on a program.

6. That replacement personnel be assigned from within the program framework, so as to retain technical experience already acquired.

7. That emphasis be placed upon the need for continuity among key contractor personnel, as well.

7. FUNCTIONAL SPECIFICATIONS AND STANDARDIZATION

Finding:

Specifications should be limited to operat[illegible]erformance requirements, and standardization should be emphasized as an effective means o[illegible]reduction.

Commercial Practice and Discussion:

The principal elements are:

Specifications describe operational performance
Manufacturer participates in development of user's specifications
Standardization emphasizes functional items

The commercial environment applies a minimum number of specifications and standards as guidelines, permitting flexibility in cost trade-off areas during the design process.

For purposes of clarification, the following terms are defined:

Standardization: A characteristic that, through a controlled interface, allows multiple usages.

Specification: Terminology that defines operating characteristics and their measures.

The profound difference between the DoD procurement cycle and that of commercial industry lies in the way they define performance. DoD specifies how; commercial customers only specify what.

The FAA offers illustrative examples of practical regulatory techniques that protect the commercial customer. The Federal Air Regulations (FARs) generally stipulate only the end results required, leaving the approach and demonstration of attainment up to the manufacturer. The FAA witnesses and approves demonstration of the final product. Such an approach greatly simplifies both the procurement function and the contractor's function.

The volume of specifications (FARs) required for the design and operation of a commercial transport is contained in approximately 290 pages. The volume of specifications required by DoD for the design of a single airplane model may require 300 to 600 first-tier MIL Specs alone, and tens of thousands of pages.

DoD's policy of specifying "how to do it" for every rivet hole and solder joint grew up during an age (the Forties) when it was clearly necessary to instruct industry in techniques for achieving

high quality and reliability. But the technological maturity of today's defense industries has made such detailed specifications not only superfluous, but counter-productive.

Another marked operating difference lies in the structure of the procurement cycle. In the Air Transport Industry, the procurement cycle for avionic equipment has many parallel paths and is iterative in nature (see Figure 1). The users who define the requirements are the airlines. Many times, the requirement is of such nature that technical discussions must be held to formulate industry standards to ensure compatibility between airborne and ground systems, between governments, etc The development of these system standards is the responsibility of the RTCA (Radio Technical Commission for Aeronautics), which operates to coordinate a joint effort of the manufacturers, government agencies and the airlines. Members of another industry group, ARINC (Aeronautical Radio, Inc.), coordinate the development of the specific characteristics. Government agencies usually adopt these standards as minimum performance criteria for certification of the equipment.

Once the system standards are established, the development of hardware standards is assigned to ARINC. Once again, the avionics manufacturers play a key role in advising on technical matters during the drafting of the "characteristics," and relate technical approach to cost to assist the airlines in making their decisions. The airlines use the resulting "characteristics" as a baseline in their hardware procurement activities with the manufacturers. It should be noted that the documents produced by the user organizations are not design specifications. They do not define how the product is to be designed and built, but rather they set forth guidelines from which the users or the manufacturers may deviate if they feel they have good reason.

There is a good deal of interaction in the establishment of the requirements, and there are several channels open to allow industry an opportunity to contribute in an area where they are the most knowledgable -- relating specific technical approaches to cost.

The application of specifications and standards in commercial industry is kept to a minimum so as not to overburden a program with detailed specifications and standards which may force delays or other unnecessary problems. Most commercial specifications and standards contain only functional requirements for equipment, documented by a relatively small number of specifications and standards. Each proposed requirement is challenged by the industry or users if they believe it is not in their best interests. These approved specifications and standards are intended as guidelines for various manufacturers and can be deviated from if a manufacturer believes a deviation is both cost-effective and acceptable to the users.

To demonstrate the difference in philosophy between DoD and a commercial business (ATI) in both the content and the application of specifications and standards, a "typical example" in the form of a military specification and its commercial counterpart appears useful (Figure 2). The specific equipments chosen are a military UHF transceiver and an airline VHF transceiver, both used for traffic control within their particular operational environments.

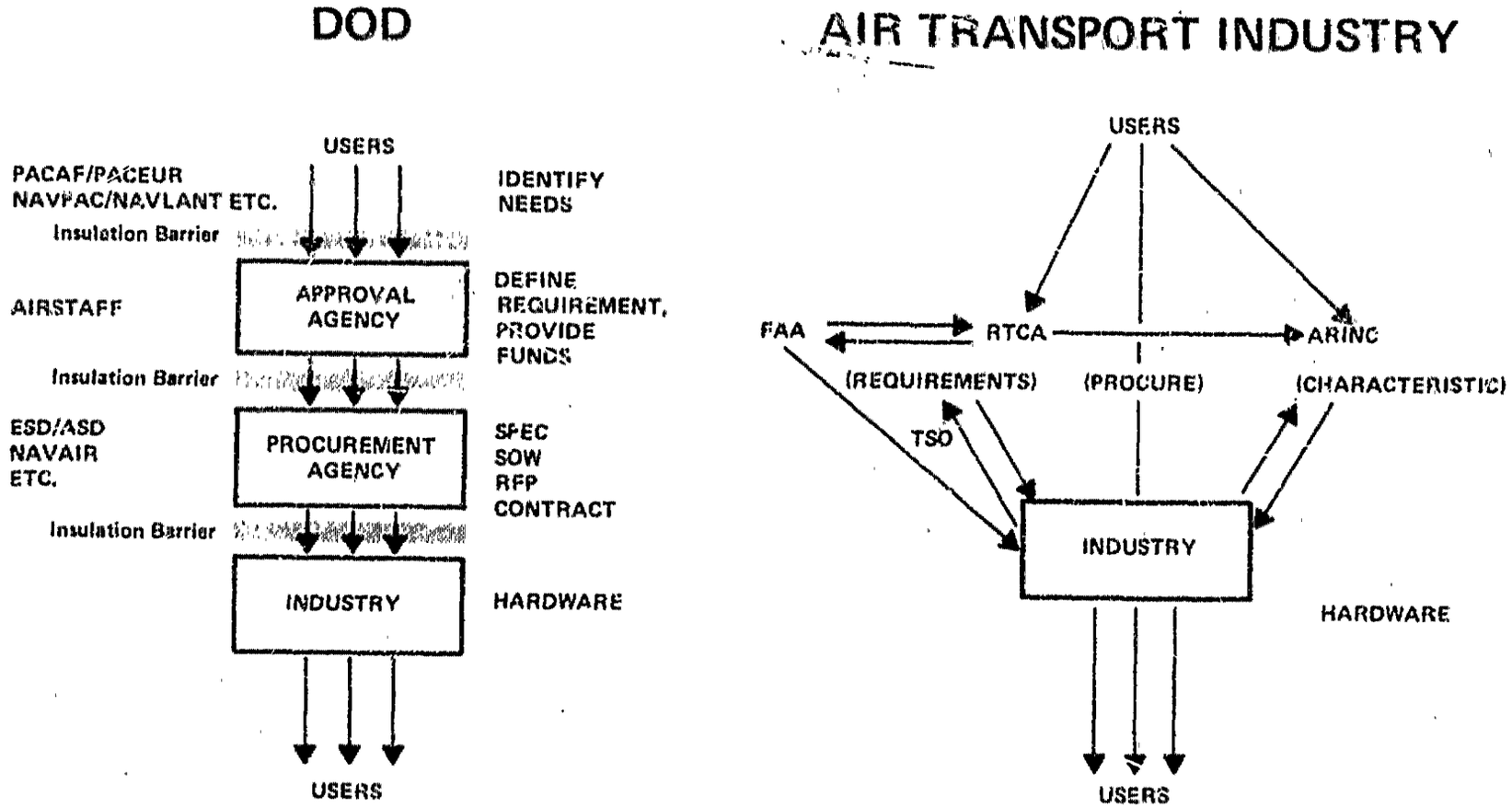

Figure 1. Basic Methods for Defining Requirements, Writing Specifications, and Procurement of New Equipment, as Practiced by the DOD and the Air Transport Industry.

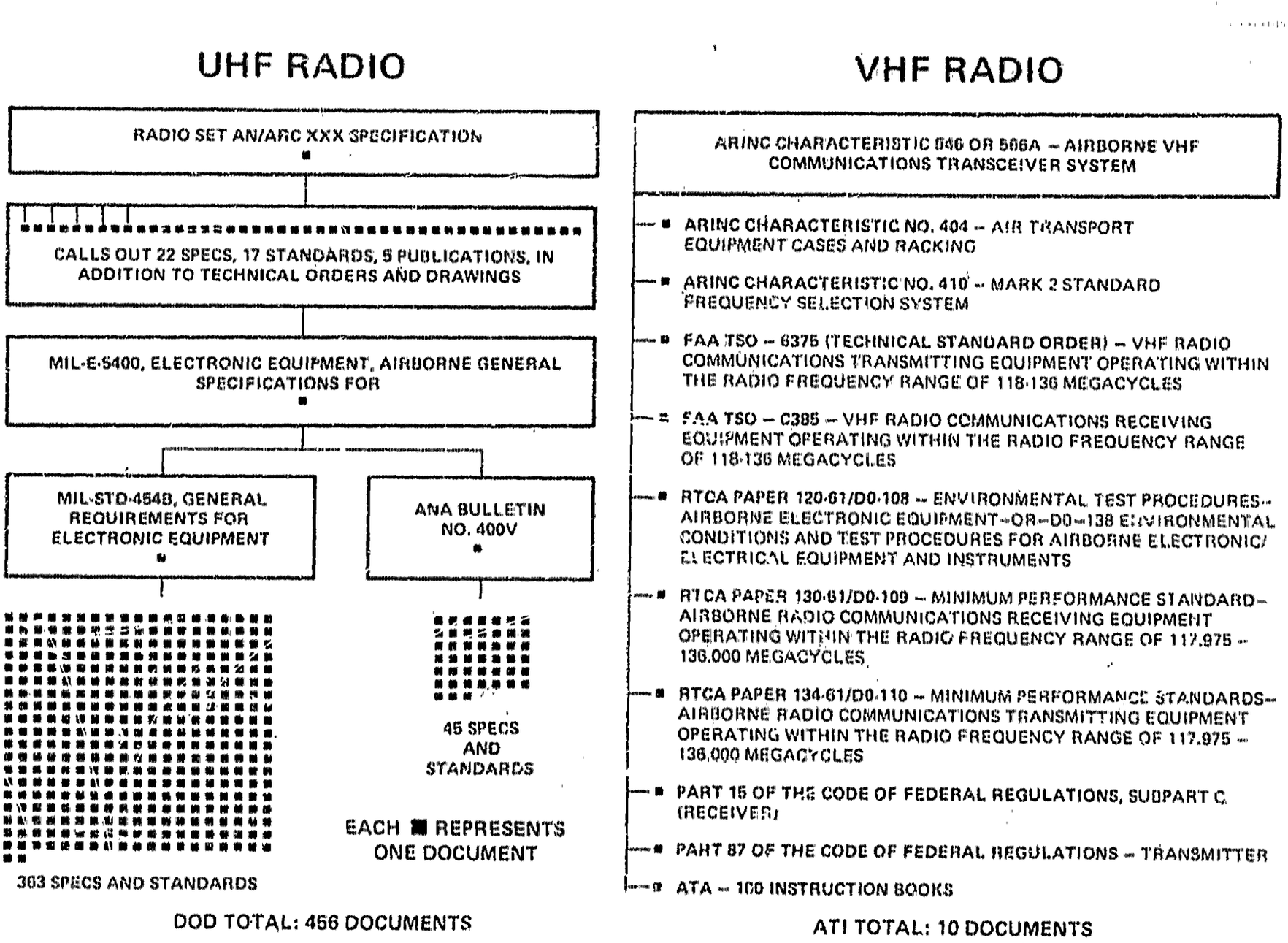

Figure 2. Comparative Specifications and Standards Requirements for Equivalent DOD and Air Transport Industry Equipment

VHF Radio, ARINC Characteristic:

Basically, ten documents cover this procurement. Examinations of these ten documents will show that the hardware definition is a functional specification only, with no attempt made to define methods, processes, materials, or components. In other words, this description relates only to form, fit, and function. ("Function" will define environmental and safety-of-flight characteristics.)

UHF Radio, DoD Specification:

It is obvious that the typical military specification goes far beyond a mere definition of form, fit, and function. In addition to design details, the military specifications also define processes, materials, components, quality procedures, and other similar requirements. For instance, there are:

4 specifications and standards on soldering
26 specifications and standards on fastener hardware
10 specifications and standards on structural welding
21 specifications and standards on adhesives

The first three specifications and standards called out by MIL-E-5400 require 13 pages just to list by title.

In the case of the commercial contract, enforcement of all documentation depends upon the guidelines set by the users. Each manufacturer complies to the degree he believes necessary to sell his product. By virtue of their procurement activity, the users of the equipment have final approval (enforcement) of what is procured. They directly procure their equipment from the manufacturer of their choice, and they only have to buy what they actually need in the way of performance -- the product which most clearly meets their requirements.

When DoD procurement agencies select commercial equipment for their use on a contract, they add to the end-item cost considerably by listing the commercial part number, assigning new Federal Stock numbers, and then reverting to the commercial part number before they can obtain the item through the DoD procurement system.

DoD applies a large hierarchy of specifications and standards that are often not strictly applicable to the product -- but they <u>are</u> applied and enforced.

As was shown in Figure 1, the DoD acquisition cycle is largely a serial process. It begins by the definition of a need by a user group. Subsequently, requirements are defined and funding is provided. A separate procurement agency then develops the specifications for the product and administers the procurement activities. The manufacturer chosen as the successful bidder designs the product to the specifications, thus completing the process. In this restrictive series chain of events, any direct

communication between the user and the manufacturer is a rare event and is, in fact, discouraged as being a confusion factor. As a result, the manufacturer may never talk to the user to determine first-hand what the user really wants and needs.

The application of specifications and standards is regimented, and requirements are quite strict. DoD goes to great lengths via tiers of specifications and standards to define detailed requirements. The procuring agency is aware they may have little control over who the manufacturers will be (perhaps a poorly qualified lowest bidder) and they feel that they must assume the worst. In addition, the requirement for commonality sometimes causes a procuring agency to change or over-specify the original user requirements in an attempt to accommodate multiple users.

The strict enforcement of all documentation related to a DoD contract is an understood fact. The ECP route is available to contractors during the course of the program, but the administrative burden involved inhibits this cost reduction activity on all but items of major impact.

In the procurement of standard commercial and modified commercial equipments, there is reason to question whether the DoD Standardization Program is cost effective. Parts identification and parts support costs increase because it is expensive and not a normal commercial practice to prepare a complete parts document, which includes commercial part numbers, Federal Item descriptions, and drawings which must then be assigned a Federal stock number before the DoD procurement agency can effect a purchase.

Recommendations:

1. That the specifications on a new procurement be functional rather than detailed. They should begin at the "zero level," with a tough challenge of requirement and cost given to each one before it is deemed applicable. Technical and cost goals should not be applied below the system level for advanced development, nor below the subsystem level during engineering development.

2. That during the development and production cycle, flexibility in the application of specifications and standards should be allowed, to permit further progress toward cost-effective goals.

3. That formal channels be established to greatly increase industry participation in both the establishment of requirements and in their applications in the form of specifications and standards.

4. That standardization be encouraged as a means of cost avoidance, but tempered by the realization that overly zealous standardization leads to excessive complexity.

5. That greater use be made of the commercial equipment base. In many instances, minor modifications to commercial equipment would prove quite adequate for non-combat equipments.

6. That greater use be made of the commercial logistics and supply base built up worldwide during the past twenty years.

Long-Term Recommendation:

That a separate procurement regulation be issued to cover commercial-type equipments. It would specify only performance requirements to meet the needs of the user. This new procurement regulation would eliminate the lengthy parts listings and numbering systems, and take advantage of producers' world-wide standard parts distribution systems. DoD could then depend on commercial parts, service and maintenance manuals, which are much simpler to follow than DoD technical manuals, and use the producer's standard method for identifying superseded parts. Thus DoD could rely on producers, and more frequently than not, the product/equipment would be more advanced, contain the latest improved materials and parts available, and be of higher quality.

APPENDIX

COMMERCIAL PRACTICE EXPERIENCE

J. Fred Bucy, Jr.	Over the past 20 years principally concerned with worldwide semiconductor market and industrial and commercial electronic equipments. For a five-year span, responsibility included military electronic equipments.
John W. Blanton	Thirty years experience in design and development of advanced military and commercial gas turbine engines. Commercial content ranged from 10% to 90% throughout the years.
G. Edwin Burks	Over 40 years experience in development and engineering of earth-moving equipment--almost entirely for commercial market.
Richard D. DeLauer	Although prior experience has been mostly military systems and equipment, present responsibility divides about 40% commercial products and 60% Government.
Alexander H. Flax	Over 30 years experience, primarily in the aerospace industry, both in Government service and commercial organizations. For the past 10 years, high executive management responsibilities related to military research and development.
Alfred V. Guillou	Twenty-five years of experience with aircraft industry have been mainly directed to military systems. For the past 10 years, responsibilities have been rather evenly divided between commercial and military programs.
Max Lehrer	Responsibilities during the past 12 years at RCA have been devoted approximately 90% to defense and 10% to commercial programs. Prior experience was with the Government and Department of Defense.
Oscar B. Marx, III	Experience and responsibilities for the past 10 years have been entirely with commercial practice, principally with automotive products.
John D. Nyquist	Over 30 years experience in manufacturing engineering, and management, of electronic communication equipment--principally avionics. (Over 75% of worldwide air transport carriers use Collins equipment.)

Charles H. Phipps	Over 15 years experience in marketing and management of semiconductor products--principally for commercial equipment. Prior experience of five years was in military electronic equipment engineering.
Joseph F. Shea	Twenty-five years of experience, primarily in defense and space programs. Commercial experience in communication, computers and displays. Present responsibilities include about 15% in commercial products.
John E. Steiner	For the past 17 years, management responsibilities have been commercial aircraft programs, of which 10% to 15% may have military derivatives. Prior experience included engineering assignments on military aircraft programs.
Robert H. Widmer	Thirty-three years experience in aerospace industry. Current and past responsibilities are divided 15% to commercial and 85% to military products.

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